EG&G ORTEC

Custom Series
Coaxial Ge(Li)
Detector Systems
Operating and Service Manual

MP MASTER
MA29073

IMPORTANT INFORMATION

Take the following steps immediately upon receiving this detector system:

1. Read and follow carefully the unpacking instructions and checkout procedures that are included in Sections 2 and 3 of this manual.

2. Fill the dewar with liquid nitrogen. Replace the LN_2 that will have evaporated and that may have been spilled during shipping. If the dewar does not have any liquid nitrogen, fill the dewar and then call the ORTEC Customer Service Department at (615) 482-4411 immediately to report this situation and obtain further instructions.

3. The plastic bag of desiccant pellets over the cryostat-preamplifier assembly absorbs any moisture that condenses when the system is moved from a cold area into a warm one. Leave this plastic bag in place until the system has been in the warmer atmosphere long enough to eliminate any further danger of condensation.

4. The cylindrical protrusion, 3/4 in. in diameter and 1 in. long, on the cryostat is the vacuum pumpout attachment. Do not tamper with this at any time. Removal of the seal voids the warranty protection.

Addendum

In Fig. 2.3 on page 4, the supply dewar at the right is to be pressurized. A means of pressure relief must be provided on this dewar so that it will not become over-pressurized in the event the tubes become blocked with ice. The pressure relief should occur at about 5 psi.

ORTEC
INCORPORATED
100 MIDLAND ROAD
OAK RIDGE, TENN. 37830
AN EG&G COMPANY

QUALITY ASSURANCE DATA

VIP Series Coaxial Ge(Li) Detector Systems

Date of Shipment 7-16-79

System Serial No. 19-827

System Model No. 8001-0821.

Recommended Operating Bias POSITIVE polarity at 2200 V.

Warranted System Resolution 2.1 keV FWHM using 1.33 MeV photons.

Warranted Peak/Compton 32/1 : Ratio of peak height to Compton plateau height.

Warranted Efficiency 8 %: Ratio of area under photopeak to that of 3" X 3" NaI(Tl), measured at 1.333 MeV, source-to-detector distance of 25 cm.

Data certified by B B Kennedy

3 MONTH WARRANTY
10/15/79

WARRANTY

ORTEC guarantees one full year of service on new detector systems. This guarantees that the detector system will meet the warranted resolution, peak-to-Compton, and efficiency specifications. ORTECs liability is limited to repair or replacement, at ORTEC option, at no charge to the user except for his shipping expense, during the term of the original warranty period only; service credit is extended for an unused portion of the warranty period from date of system return to ORTEC. No systems will be accepted for warranty action without prior approval by ORTEC of shipping arrangements in order to ensure safe arrival. Warranty is void if: cryostat has been out of contact with liquid nitrogen for more than 5 minutes; vacuum valve has been opened; detector has incurred radiation damage; system has been subjected to mistreatment; system has not been packaged properly for return; or system is received at ORTEC without any liquid nitrogen in the dewar.

CAUTION

Cryostats Models 80 and 81 can be damaged by unnecessary overfilling, if it is continued long enough to lower the temperature of the flange appreciably. Never allow an automatic filling to proceed without personal supervision. Any extended overfilling of the LN_2 can freeze the Viton O-ring and cause loss of vacuum, which may seriously damage the detector.

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Sent back to ORTEC 5-20-79 would not hold bias ORTEC measured 200pf suspects warm up (2 to 3 days) — L15 482-4411 Mr. Gary Gibbs Sandy Wyman (mfg) A (Vance Harmon Customer serv. mgr.

QUALITY ASSURANCE DATA

Custom Series Coaxial Ge(Li) Detector Systems

Date of Shipment 2-24-79

System Model No. 8001-0821 . System Serial No. 19-827

7-10-79 Settled on $450.00 charge will call Jan Eades at ORTEC

Detector Size 42.15 mm dia. by 35 mm length.

Drift Depth 16 mm. Diffusion Depth 1.0 mm.

Total Active Volume 42.6 cc.

Absorbing Layers:

Aluminum .5 mm. Teflon 1 mm. Germanium dead layer — mm.

Window to Detector Distance 5 mm.

Total Capacitance 28 pF at 1000 V.

Recommended Operating Bias positive polarity at 2200 V.

Measured Total Resolution 2.03 keV FWHM using 1.33mev photons at 3 μsec amplifier time constant with ORTEC Amplifier System with a noise width of 1.04 keV.

Measured Peak/Compton 34/1 : Ratio of peak height to Compton plateau height.

Measured Efficiency 8.8 %: Ratio of area under photopeak to that of 3" x 3" NaI(Tl), measured at 1.333 MeV, source-to-detector distance of 25 cm.

Warranted System Resolution 2.1 keV FWHM using 1.33mev photons.

Warranted Peak/Compton — : Ratio of peak height to Compton plateau height.

Warranted Efficiency 8 %: Ratio of area under photopeak to that of 3" x 3" NaI(Tl), measured at 1.333 MeV, source-to-detector distance of 25 cm.

3 months warr

Data certified by WS Crowley

WARRANTY

ORTEC guarantees one full year of service on new detector systems. This guarantees that the detector system will meet the warranted resolution, peak-to-Compton, and efficiency specifications. ORTECs liability is limited to repair or replacement, at ORTEC option, at no charge to the user except for his shipping expense, during the term of the original warranty period only; service credit is extended for an unused portion of the warranty period from date of system return to ORTEC. No systems will be accepted for warranty action without prior approval by ORTEC of shipping arrangements in order to ensure safe arrival. Warranty is void if: cryostat has been out of contact with liquid nitrogen for more than 5 minutes; vacuum valve has been opened; detector has incurred radiation damage; system has been subjected to mistreatment; system has not been packaged properly for return; or system is received at ORTEC without any liquid nitrogen in the dewar.

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Cryostats Models 80 and 81 can be damaged by unnecessary overfilling, if it is continued long enough to lower the temperature of the flange appreciably. Never allow an automatic filling to proceed without personal supervision. Any extended overfilling of the LN_2 can freeze the Viton O-ring and cause loss of vacuum, which may seriously damage the detector.

Custom Series
Coaxial Ge(Li) Detector Systems

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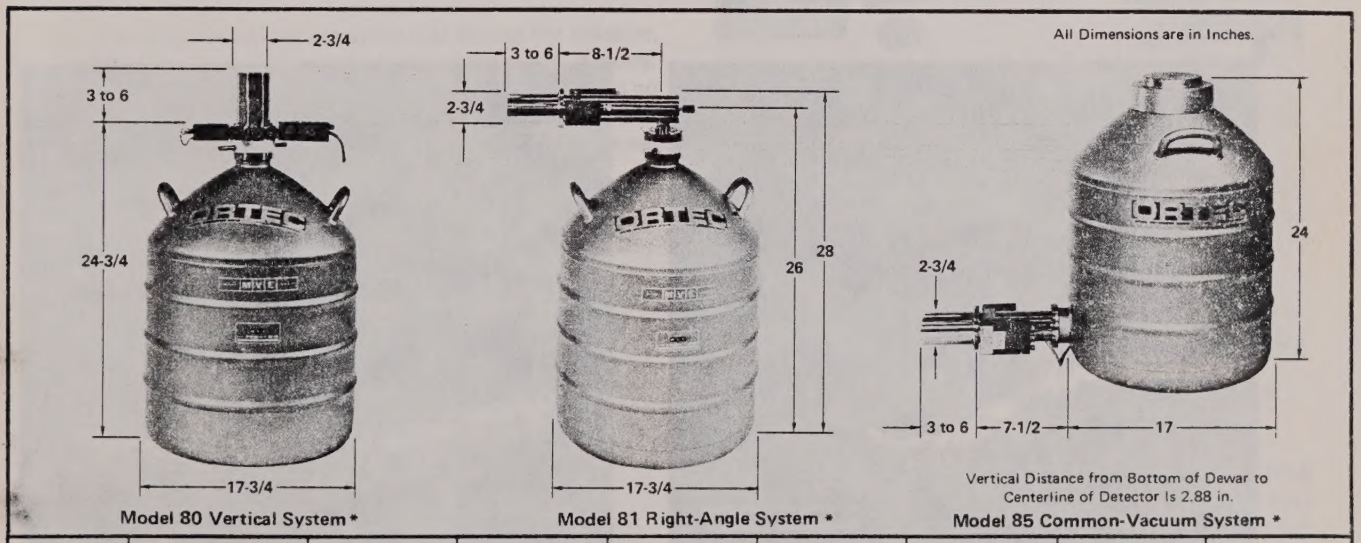
1. GENERAL

An ORTEC Germanium Detector system may have any one of the three basic configurations shown in Fig. 1.1. The main difference between these systems is the location of the active detector element. In each configuration the Ge(Li) detector element is located concentrically in the end cap with its front face approximately 5 mm from the outer surface of the end cap.

The preamplifier and the high-voltage filter are connected electrically to the detector through vacuum seals. The cryostat assembly, which is designed to keep the detector at a cryogenic temperature, has been manufactured carefully with a sealed vacuum that will be maintained for many years under normal conditions.

An ORTEC 729A Liquid Nitrogen Level Monitor is available as an accessory to protect the Ge(Li) Detector system from warmup due to loss of nitrogen in the dewar. A thermistor probe in the dewar attached by a cable through the nitrogen transfer collar to the 729A senses the presence of liquid nitrogen. When the liquid nitrogen in the dewar falls below a safe level, an alarm sounds and a red light on the front panel of the control module flashes a warning.

Although all these systems are quite rugged, certain precautions must be observed to prevent damage. For example, the cryostat must not be removed from contact with liquid nitrogen for more than a few seconds or it will condense moisture from the air and form an insulating ice coating. The preamplifier and high-voltage filter connections to the detector are made through very fragile metal-to-glass seals and must not be subjected to any pressure that could damage these delicate seals. Other precautions are indicated at the appropriate places in the Sections 2–4; follow the



Model 80 Vertical System *

Model 81 Right-Angle System *

Model 85 Common-Vacuum System *

Model No.	Type	Cryostat Weight (lb)	LN_2 Volume (liters)	LN_2 Weight (lb)	Dewar Weight (lb)	Typical Holding Time (days)	Total Weight Full of LN_2 (lb)	Shipping Weight (lb)
80	Vertical System	5.4	31	53	33	28	91.4	166.1
81	Right-Angle System	7.3	31	53	33	28	93.3	168
85	Common-Vacuum System	32**	30	51	32**	21	85	158

*The dimensions represent average values. Crystal size influences cryostat size; dewars are supplied with tolerances of ±1/2 in. and the geometry will vary accordingly.

**Includes weight of dewar and cryostat.

Fig. 1.1. Standard Cryostat Configurations and Specifications.

steps in all directions carefully to both prevent damage and obtain the ultimate in operation from your detector system.

When any detector configuration is used in an energy spectroscopy system, the detector element absorbs the energy from an incident gamma-ray or x-ray event and generates a current pulse with an amplitude that is proportional to the absorbed energy. This pulse is processed through the preamplifier that is attached to the detector assembly and then through a main amplifier and into a multichannel analyzer. The analyzer measures the amplitude of each pulse and stores a record of the event in its memory. After a sufficiently large number of events have been detected, measured, and stored, the data in the multichannel analyzer represent a spectrum of energies vs frequency of repetition.

For reference, Fig. 1.2 is a spectrum obtained for ^{60}Co, using an ORTEC Ge(Li) Coaxial Detector. The range of energies in the spectrum is from 0 through about 1.5 MeV and the two principal energy lines for the source, at 1.17 and 1.33 MeV, are seen clearly as high peaks in the spectrum. The vertical deflections in the display are logarithmic rather than linear. This practice is standard because it permits the observation of small peaks, resulting from relatively few counts, within the spectrum for the major peaks, which result from very high count levels.

Figure 1.3 shows the portion of interest in the spectrum of Fig. 1.2. It was obtained by using a biased amplifier between the main amplifier and the multichannel analyzer in the system to suppress all energies below about 1.1 MeV and to expand the range from 1.1 MeV to about 1.4 MeV into the full range of the multichannel analyzer. Any energies outside these limits are simply not included in the spectrum, but the details of the photopeaks are much easier to discern in this partial spectrum.

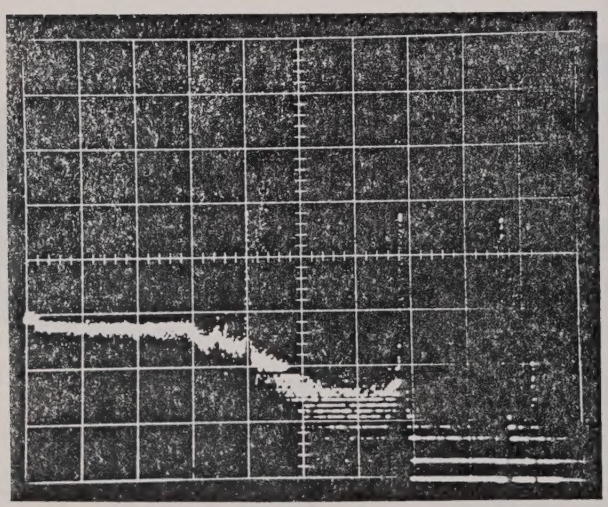


Fig. 1.2. Full Spectrum Taken with ORTEC Ge(Li) Coaxial Detector on ^{60}Co.

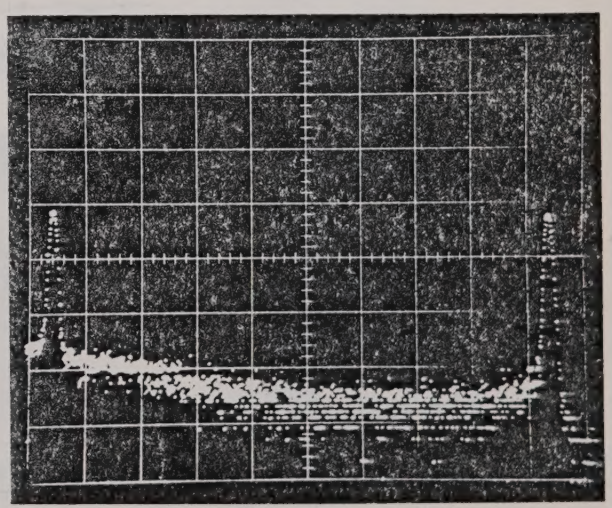


Fig. 1.3. Expanded Portion of Interest in the ^{60}Co Spectrum.

2. RECEIVING AND INSPECTION

2.1. GENERAL

Each ORTEC Ge(Li) Coaxial Detector system is shipped in a custom-built wooden crate to protect all of the system elements. The crate should have remained upright during shipment to prevent liquid nitrogen spillage. Since there will have been some normal evaporation of the liquid nitrogen, the amount depending on the total shipping time, it is normal for the dewar to be less than full at the time the system is received. **Protect the detector by replacing the liquid nitrogen that has been lost during shipping as quickly as possible.** Specific instructions for refilling the dewar according to the particular system configuration are given below.

2.2. MODEL 80 VERTICAL SYSTEM

1. Six wing nuts are accessible through the sides of the crate near the floor. Remove them and carefully lift the cover straight up.

2. Cut and remove the strapping that secures the cryostat, preamplifier, and high-voltage filter to the dewar handles. Do not remove the plastic bag of desiccant until there is no longer danger of condensation. The system will look like that in Fig. 2.1 after the bag of desiccant has been removed. Keep it in an upright position at all times.

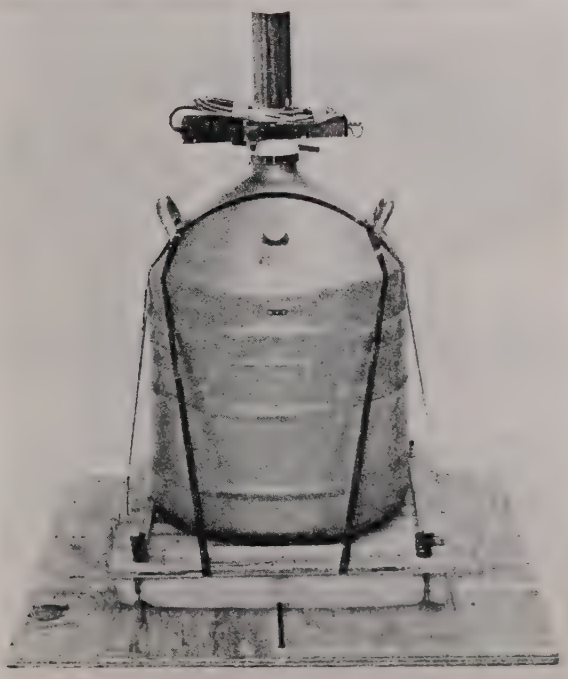


Fig. 2.1. Model 80 System with Crate, Desiccant, and Upper Strapping Removed.

3. Three nuts fasten the mounting screws under the dewar neck tube flange as shown in Fig. 2.2. Remove these three nuts and lift the cryostat up and out of the dewar and inspect the dipstick briefly. Return the cryostat to its normal position in the dewar as soon as you have determined that the dipstick is cold or warm; if it is cold, the liquid nitrogen in the dewar has not been totally depleted and the dewar should be refilled immediately. Fasten the assembly with the three screws and nuts to permit pressure filling, and see step 4. If the dipstick is warm, this constitutes a damaged shipment; refill the dewar with liquid nitrogen to prevent any further damage and immediately contact the ORTEC Customer Service Department at (615) 482-4411 to report this condition and obtain further instructions.

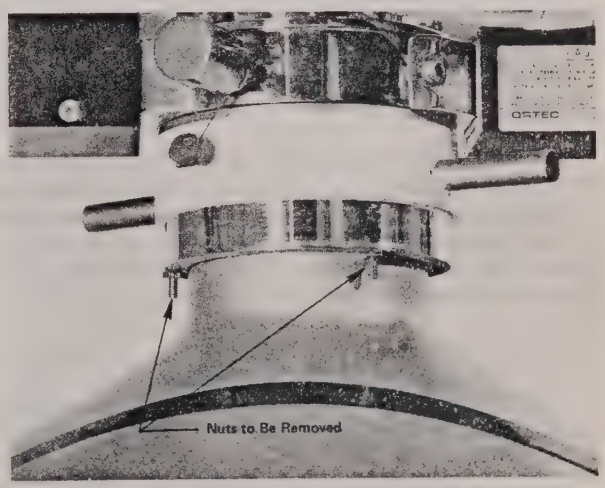


Fig. 2.2. Nuts to Be Removed for Access to Dipstick.

4. Figure 2.3 suggests a practical arrangement for filling the dewar with liquid nitrogen under pressure. The two stainless steel tubes that project through the rubber collar are for filling and venting and are interchangeable. Attach a short length of tubing to the vent tube to carry the cold gas and overflow away from the preamplifier and high-voltage filter to prevent moisture condensation on and in these components. Attach tubing from the outlet of a filling dewar to the fill tube on the nitrogen transfer collar of the detector assembly. To initiate the transfer, pressurize the filling dewar with dry nitrogen gas, 3 to 5 psig, and continue until liquid nitrogen exhausts from the vent tube; then relieve the pressure to stop the transfer. For safety reasons air or oxygen should not be used for pressurization. The transfer requires only a few minutes with this system. ORTEC recommends that the transfer process be monitored because a continued attempt to transfer liquid nitrogen after the filling dewar has been emptied will blow warm nitrogen gas into the cryostat's dewar and will finally

Fig. 2.3. Tubing Arrangement for Liquid Nitrogen Transfer.

warm up the detector. This will trigger the alarm in the 729A Liquid Nitrogen Level Monitor if it is included in the system.

5. Inspect the assembly for physical damage that might have occurred during shipment. Do not proceed with electrical connections and testing until at least 20 minutes after filling because there is a danger of moisture condensation in the high-voltage circuit, and all of this moisture must be evaporated before high voltage is applied.

6. **Do not tamper with the vacuum pumpout attachment!** The vacuum pumpout attachment projects through the cryostat flange near the preamplifier and is covered with a blue sleeve 3/4 in. in diameter and 1 in. long. The blue sleeve is wired and secured with a tamper-proof seal and should not be removed (see "Warranty" and "Important Information" at the front of this manual).

7. Cut the straps that hold the dewar to the floor of the crate and remove the complete detector assembly from the crate. Remove the pad from the crate under the dewar location and use it as a shock mounting under the dewar at its operating location. Store the crate in a convenient location for possible reuse at a later time.

2.3. MODEL 81 RIGHT-ANGLE SYSTEM

1. Six wing nuts are accessible through the sides of the crate near the floor. Remove them and carefully lift the cover straight up.

2. Cut and remove the strapping that secures the cryostat, preamplifier, and high-voltage filter to the dewar handles. Do not remove the plastic bag of desiccant until there is no longer any danger of condensation. The system will look like that in Fig. 2.4 at this time. Keep it in an upright position.

3. There are three mounting screws through the outer perimeter of the cryostat flange that retain the cryostat and attached rubber collar to the dewar. Loosen these three screws and remove the assembly briefly from the dewar to inspect the dipstick. Since the molded silicone rubber section of the collar is a snug fit in the dewar neck, a firm vertical pull with a slight rotary motion may be required to free it. Return the assembly to its normal position in the dewar as soon as you have determined that the dipstick is cold or warm; if it is cold, the liquid nitrogen in the dewar has not been totally depleted and the dewar should be refilled immediately. Fasten the assembly with the three screws to permit pressure filling, and see step 4. If the dipstick is warm, this constitutes a damaged shipment; refill the dewar to prevent any further damage to the detector and immediately contact the ORTEC Customer Service Department at (615) 482-4411 to report this condition and obtain further instructions.

4. Figure 2.3 suggests a practical arrangement for filling the dewar with liquid nitrogen under pressure. The two stainless steel tubes that project through the rubber collar are for filling and venting and are interchangeable. Attach a short length of tubing to the vent tube to carry the cold gas and overflow away from the preamplifier and high-voltage filter to prevent moisture condensation on and in these components. Attach tubing from the outlet of a filling dewar to the fill tube on the nitrogen transfer collar of the detector assembly. To initiate the transfer, pressurize the

Fig. 2.4. Model 81 System with Crate Top and Upper Strapping Removed.

filling dewar with dry nitrogen gas, 3 to 5 psig, and continue until liquid nitrogen exhausts from the vent tube; then relieve the pressure to stop the transfer. For safety reasons air or oxygen should not be used for pressurization. The transfer requires only a few minutes with this system. ORTEC recommends that the transfer process be monitored because a continued attempt to transfer liquid nitrogen after the filling dewar has been emptied will blow warm nitrogen gas into the cryostat's dewar and will finally warm up the detector. This will trigger the alarm in the 729A Liquid Nitrogen Level Monitor if it is included in the system.

5. Inspect the assembly for physical damage that might have occurred during shipment. Do not proceed with electrical connections and testing until at least 20 minutes after filling because there is a danger of moisture condensation in the high-voltage circuit, and all of this moisture must be evaporated before high voltage is applied.

6. **Do not tamper with the vacuum pumpout attachment!** The vacuum pumpout attachment is covered with a blue sleeve 3/4 in. in diameter and 1 in. long. The blue sleeve is wired and secured with a tamper-proof seal and should not be removed (see "Warranty" and "Important Information" at the front of this manual).

7. Cut the straps that hold the dewar to the floor of the crate and remove the complete detector assembly from the crate. Remove the pad from the crate under the dewar location and use it as a shock mounting under the dewar at its operating location. Store the crate in a convenient location for possible reuse at a later time.

2.4. MODEL 85 COMMON VACUUM SYSTEM

1. Six wing nuts are accessible through the sides of the crate near the floor. Remove them and carefully lift the cover straight up. Do not remove the plastic bag of desiccant until there is no further danger of condensation. The system will look like that in Fig. 2.5 at this time.

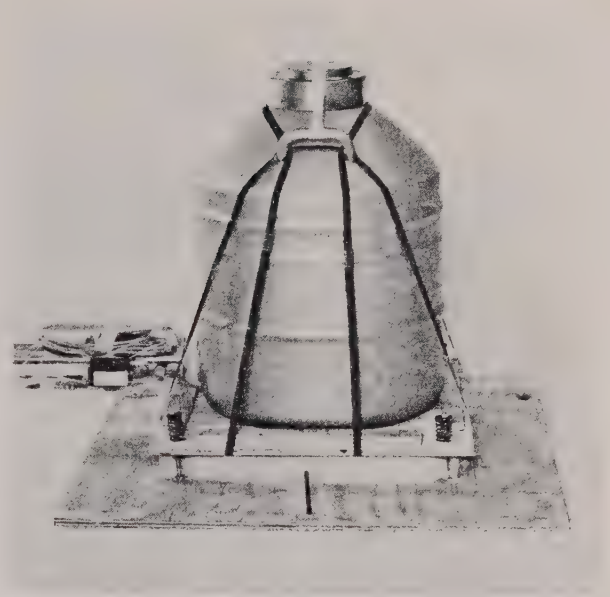


Fig. 2.5. Model 85 System with Crate Top Removed.

2. Remove the tape that secures the dewar cover to the handles. Lift the cap off the dewar and check for liquid nitrogen. A wooden yardstick or dowel can be gently inserted through the top of the dewar and used as a dipstick to measure the depth of liquid nitrogen in the dewar. If the optional 729A Liquid Nitrogen Level Monitor probe has been installed in the dewar, be very careful to protect the fragile thermistor at the end of the probe inside the dewar by inserting the dipstick gently and straight down into the dewar. If there is liquid nitrogen in the dewar, completely fill the dewar and replace the dewar cap. If there is no liquid nitrogen in the dewar, this constitutes a possibly damaged shipment; refill the dewar with liquid nitrogen to prevent any further damage to the detector and immediately contact the ORTEC Customer Service Department at (615) 482-4411 to report this condition and obtain further instructions.

3. Inspect the assembly for possible physical damage during shipment. Do not proceed with electrical connections and testing until at least 20 minutes after filling because there is a danger of moisture condensation in the high-voltage circuit if any liquid nitrogen has spilled during the refilling, and all of this moisture must be evaporated before high voltage is applied.

4. **Do not tamper with the pumpout attachment!** The vacuum pumpout attachment near the preamplifier is covered with a blue sleeve 3/4 in. in diameter and 1 in. long. The blue sleeve is wired and secured with a tamper-proof seal and should not be removed (see "Warranty" and "Important Information" at the front of this manual).

5. Cut and remove all the shipping straps and remove the detector assembly from the crate. Remove the pad from the crate under the dewar location and use it as a shock mounting under the dewar at its operating location. Store the crate in a convenient location for possible reuse at a later time.

3. CHECKOUT AND OPERATION

3.1. GENERAL

After the dewar has been refilled to its capacity and the subsequent steps taken as described in Section 2, install the detector in an energy spectroscopy system and operate the system to check the specifications that are included in the Quality Assurance Data Sheet at the front of the manual. This will accomplish two purposes: assure that no damage has been incurred during shipment and provide the basic orientation to the use of a ^{60}Co source for testing the system. The basic specifications are based on spectrum measurements made with a ^{60}Co source.

The electronic system to be used for the measurements includes the detector with its attached preamplifier and high-voltage filter, a main amplifier, an optional biased amplifier, a multichannel analyzer, a precision pulse generator, a detector bias power supply, and an oscilloscope. The typical system arrangement is shown in Fig. 3.1.

The connections between the preamplifier and the detector and between the high-voltage filter and the detector are made automatically through the cryostat mounting. Detector bias (operating voltage) is furnished from the detector bias power supply and must be cabled to the type SHV connector on the high-voltage filter. Connect the output from the precision pulse generator to the Test input of the preamplifier. Two connections are required between the preamplifier and the main amplifier: a BNC signal cable, which uses RG-62B/U cable or equal and goes from the E Output connector on the preamplifier to an Input connector on the main amplifier, and a connection that uses the captive power cable in the preamplifier to obtain power from the Preamp Power connector on the main amplifier.

Use a BNC tee, if necessary, to connect the unipolar output of the main amplifier to both the oscilloscope and the multichannel analyzer or biased amplifier (if used). If the main amplifier includes a Unipolar Output monitor test point on the front or rear panel, it can be used for the oscilloscope connection and a BNC tee is not then required. Use a main amplifier gain of 40 for preliminary testing. If a biased amplifier is included in the system, set its gain at 1 for preliminary testing and reduce its bias to zero.

The system should be dc-coupled all the way from the preamplifier through the multichannel analyzer. An inadequate electronics system, or one that is not completely dc-coupled, will not check the specifications adequately. Furnish power to all equipment, including the oscilloscope, from the same ac power source to prevent ground loops.

The major reason for not achieving the same measured resolutions as those measured before shipment is the use of less than state-of-the-art electronics. The gain stability of the system must be better than 1 part in 10^4. The use of a precision pulse generator, connected to the Test input on the preamplifier, can demonstrate the system stability. All the following tests assume that the electronic equipment has the required stability.

The measurement accuracy that will be used to test for resolution requires a multichannel analyzer with a sufficient number of channels to provide at least 5 (and preferably 10 or more) channels in the photopeak at the FWHM level. A multichannel analyzer with at least 4K channels is recommended.

3.2. TEST BEFORE APPLICATION OF BIAS

Before applying bias to the detector, apply power to the other components in the system. Observe the unipolar output from the main amplifier on the oscilloscope. Adjust the oscilloscope gain to observe the "grass" or "white

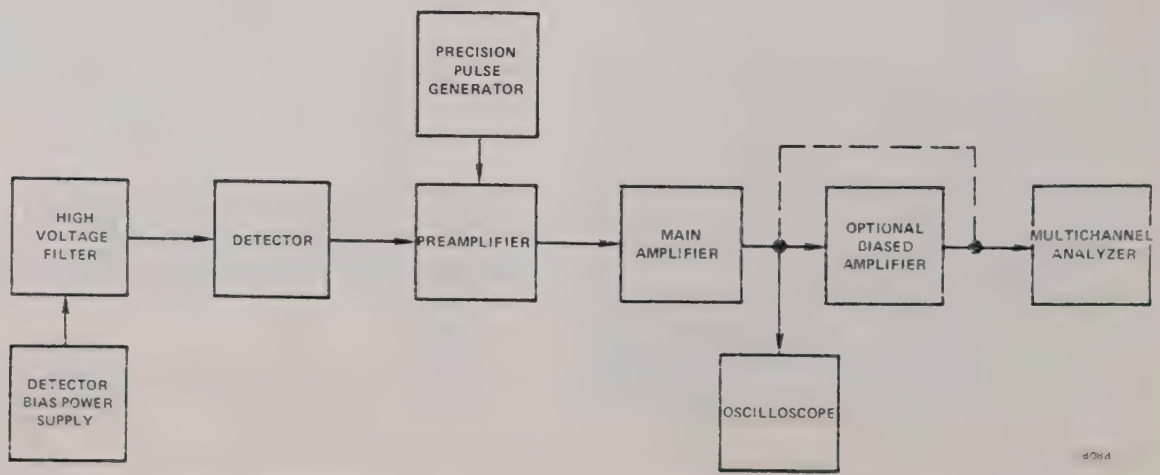


Fig. 3.1. Interconnection of Components in a Typical Energy Spectroscopy System.

noise" of the system. The oscilloscope can be triggered by the power line frequency for these tests, and the vertical gain snould be adjusted for a signal height of 1 to 2 cm.

If the oscilloscope is being triggered from an ac power line source, a sine wave at either 60 or 120 Hz with superimposed noise indicates a ground loop in the system. Find and eliminate the ground loop. If there is any ripple at these frequencies, it should be very small in comparison to the amplitude of the white noise.

Apply about 200 V positive bias to the detector. The noise amplitude should decrease, because the detector capacitance is reduced as bias is increased. Application of the wrong bias polarity can cause the noise amplitude to either increase greatly or drop completely to zero. (This condition can also occur if the detector has been subjected to warmup during shipping and therefore no longer behaves as a good diode even when the proper polarity is applied.)

If the detector bias polarity is correct and the reaction is normal, increase the detector bias gradually in (typical) steps of 200 V while observing the oscilloscope. The noise amplitude should normally continue to decrease down to a minimum in the range of 200 to 1000 V. If during the stepwise voltage increase to the final recommended value the noise disappears and does not reappear within 15 seconds, reduce the bias immediately in decrements of 100 V until the noise reappears. The detector may be tested for its resolution capabilities at this reduced bias level.

When the bias has been raised to that specified in the Quality Assurance Data Sheet, the noise amplitude may have increased above the minimum level noted above, but the increase should not exceed 10%. This small contribution is directly attributable to the detector noise contribution and should always remain small.

3.3. DETECTOR RESOLUTION MEASUREMENTS

Place a ^{60}Co source near the detector end cap. Adjust the gain(s) of the main amplifier (and biased amplifier if included) and the conversion gain of the multichannel analyzer to bring both the 1.17- and 1.33-MeV peak areas into the multichannel analyzer range, with about 1000 channels of spacing between the peaks similar to those in Fig. 1.3.

The system calibration can now be calculated in keV/channel since both energy peaks are identified by channel numbers and the spread between the peaks is 159.3 keV. Turn on the pulse generator and adjust it to locate a peak between the two photopeaks in the spectrum. Turn off the pulse generator.

Use the oscilloscope to verify that the outputs from both tne main amplifier and the biased amplifier are within their linear ranges and have not suffered any distortion and that the pole zero has been adjusted properly (see Section 4). The pulses must be within the linear ranges of both these instruments for satisfactory operation.

Connect a scaler or count ratemeter at the main amplifier output. Position the ^{60}Co source so that the total amplifier count rate does not exceed 1000 counts/sec. Do not operate the pulser. Set the Baseline Restorer switch on the main amplifier at Low.

Accumulate a spectrum in the multichannel analyzer that has several thousand counts in the 1.33-MeV peak channel. Count the number of channels in the width at the half-maximum count level (FWHM). Calculate the system resolution by multiplying the number of channels times the keV/channel system calibration. Compare this measured resolution with that given for the detector in the Quality Assurance Data Sheet at the front of the manual.

Now accumulate a pulser peak to several thousand counts maximum. Measure its resolution at FWHM by the same process. Compare this with the information for pulser peak resolution on the Quality Assurance Data Sheet. Measure the pulser peak both with and without the ^{60}Co source. Any significant difference in the resolutions for these two conditions indicates a count rate problem in the electronics.

Failure to obtain the indicated resolutions during these measurements can indicate any one of a variety of problems in the electronic circuits. Detailed information is included in "Troubleshooting Suggestions," Section 4.3 of this manual, to aid in identification of the probable cause for each type of problem, together with suggestions for remedies after the problem has been identified.

If it appears that the resolution specification has not been met, recheck the shaping time constants of the amplifier after consulting its instruction manual. A reduction of the detector bias by about 500 V can aid in determining whether there is or is not a possible detector breakdown at the higher voltage that could be causing some loss of resolution.

3.4. PEAK-TO-COMPTON MEASUREMENT

The measurement of the peak-to-Compton ratio is based on the same energy peak at 1.33 MeV that was used for the resolution measurements in Section 3.3. The ratio is found by dividing the number of counts in the 1.33-MeV peak channel by the average number of counts in the channels for the range from 1.04 through 1.10 MeV, which is the Compton region associated with the 1.33-MeV peak. The range of the multichannel analyzer must be adiusted to include the peak channel and the range of interest in the Compton plateau. Accumulate the spectrum until there are several thousand counts in the peak channel and then calculate the ratio based on the information in the spectrum.

Normally, the calculated peak-to-Compton ratio can be expected to match the quoted specification if the resolution specification has been met. A loss of about 10% in the resolution of the peak can be expected to produce a comparable loss of about 10% in the peak-to-Compton ratio. If there is a reduction in the peak-to-Compton ratio without a corresponding reduction of resolution, this is probably due to the presence of some absorbing material in the vicinity of either the detector or the source or to background from concrete walls, or to the presence of some other radiation sources. An adjacent absorbing material can increase the Compton background and can thus reduce the peak-to-Compton ratio. Any contribution of energy in the range of interest that is furnished from extraneous radiation sources other than the ^{60}Co will, of course, also build up the count level that is used for a reference. For this measurement be sure that the detector is at least 3 ft away from any physical objects and that no other radiation sources are in the vicinity of the detector.

3.5. EFFICIENCY MEASUREMENT

The standard ORTEC procedure for efficiency measurements is an absolute measurement procedure that is defined in IEEE Standard 325 (1970), "Standard Test Procedures for Germanium Gamma-Ray Detectors." A calibrated ^{60}Co source is placed exactly 25 cm from the front face of the detector element and the count rate is determined. Since the distance from the detector element face to the outer face of the end cap is listed in the Quality Assurance Data Sheet, the 25-cm distance can be established accurately. The count rate is then compared with the count rate that would be obtained with a 3 X 3 NaI(Tl) scintillation detector, which is known to be 1.2×10^{-3} times the total disintegration rate of the calibrated ^{60}Co source.

For an accurate measurement the calibrated ^{60}Co source must be positioned at the correct distance and centered on a line that is concentric with the detector element. The efficiency ratio, according to the standard procedure, is obtained by comparing the integrated total number of counts in the 1.33-MeV photopeak at the FWHM level with the equivalent calculated count rate for the NaI(Tl) detector.

3.6. TIMING CHARACTERISTICS CHECKOUT

The method recommended for determining the timing characteristics of a Ge(Li) detector is a special form of constant-fraction timing, known as Amplitude Risetime Compensated, or simply ARC, timing. The ARC timing method eliminates to first order the timing uncertainty due to rise-time and pulse-height variations. The method shown below can be used to check your Ge(Li) detector timing characteristics. Additional information on timing with Ge(Li) detectors is available in the ORTEC Application Note 31.

Figure 3.2 shows a typical system for measuring the time resolution of a germanium detector. The stop channel is

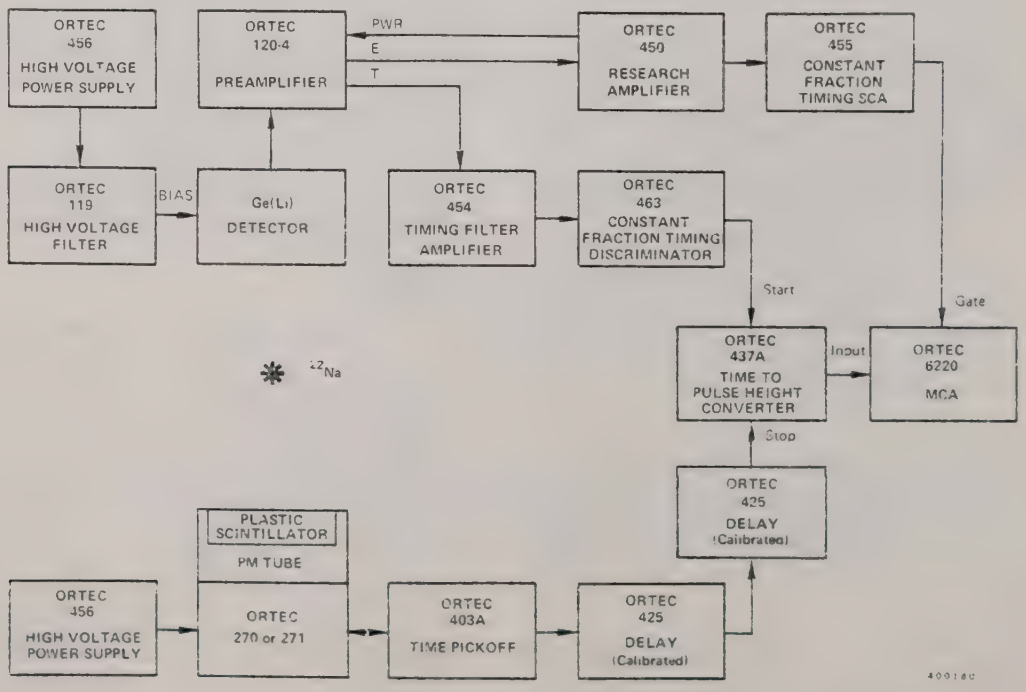


Fig. 3.2. Typical System for Measuring Time Resolution of a Germanium Detector.

used for time reference and should consist of a fast plastic scintillator mounted on a relatively fast photomultiplier tube (e.g., $\tau_R \leq 10$ nsec). A typical combination that would furnish these characteristics is a Naton-136 scintillator and an RCA 8575 photomultiplier tube. The signal from the PM tube should be processed by a constant fraction discriminator such as is furnished in the ORTEC 270 and 271 Constant Fraction Timing PM Tube Bases. The signal from either of these will be obtained through an ORTEC 403A Time Pickoff Control.

The timing reference pulse should be delayed before it enters the stop input of the time-to-pulse-height converter. Several calibrated delays are required for this function in order to provide a calibration of the time axis.

The germanium detector signal is available through two preamplifier outputs simultaneously, marked E and T. The T output is routed to a fast shaping amplifier, the ORTEC 454, with a differentiation time constant equal to approximately the fastest rise time observable at the preamplifier output. The differentiated signal is then routed to the ARC timing discriminator. These shaping parameters are shown in Fig. 3.3.

The E signal from the preamplifier is routed through an amplifier and a timing single channel analyzer. The single-channel analyzer output will occur when a measurement in the time-to-pulse-height converter is made with signals for an energy of interest, keyed with the energy level that is used. The SCA output can then be used to gate the MCA to accept the corresponding analog output from the TPHC and to obtain a spectrum of the time measurements. Sodium-22 is suggested as a source of coincident gamma rays, and the single-channel analyzer should be set on the 511-keV gamma-ray peak with a 10% window width.

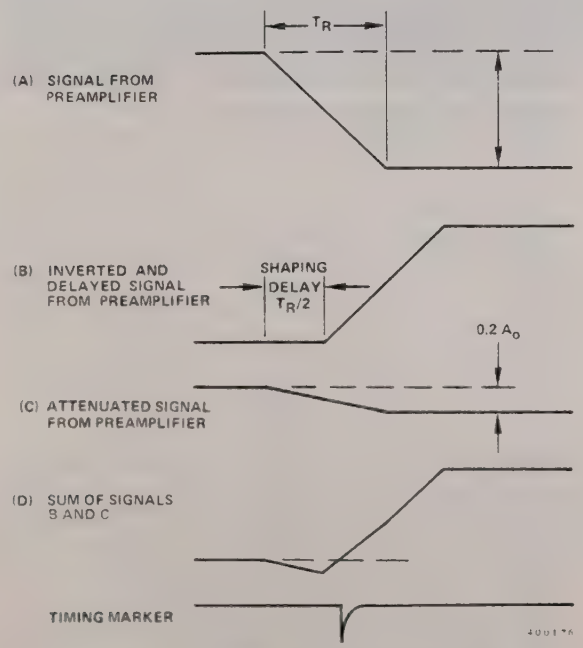


Fig. 3.3. Signals Used in ARC Timing.

A typical timing spectrum that demonstrates the resolution of the germanium detector is shown in Fig. 3.4. Use a system similar to the one shown in Fig. 3.2 and accumulate the spectrum. Operate the system until there are at least 2000 counts in the peak channel in the analyzer; the peak channel in Fig. 3.4 shows about 7200 counts. For adequate measurement there should be at least 5 channels of width at the half-maximum level in the spectrum (3600 counts in Fig. 3.4). The controls that affect this distribution are the time range of the TPHC and the conversion gain of the analyzer. After calibrating the time axis with at least two calibrated delays, measure the FWHM and the FWTM in units of nanoseconds, as shown in Fig. 3.4.

The following parameters should be specified for a timing test in order to assure reproducibility:

Germanium detector bias voltage
Differentiation time of the ORTEC 454 Timing Filter Amplifier
Disc Level setting on the 463
The number of events per second recorded in the analyzer

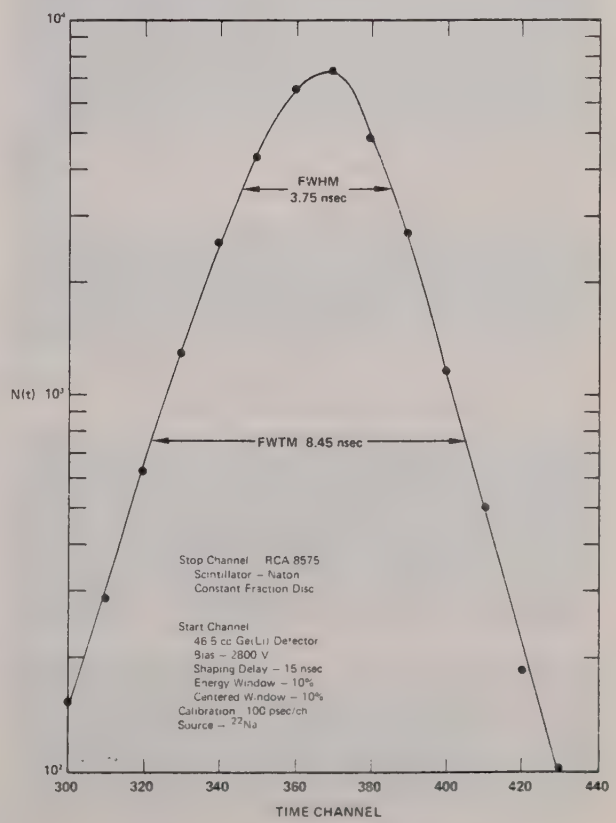


Fig. 3.4. Typical Timing Spectrum.

4. MAINTENANCE AND TROUBLESHOOTING

4.1. LIQUID NITROGEN

Establish a weekly filling schedule to be certain that warmup cannot occur.

There are several advantages of establishing a weekly schedule for refilling the dewar with liquid nitrogen, even though the holding time is about three times that interval. (1) The use rate is low enough (~1.1 to 1.3 liters/day) that this frequency will always assure an adequate supply. (2) There is never any question about whether it is or is not time for refilling. (3) Any excess loss rate, which can indicate a vacuum problem in the cryostat, will be discovered quickly so that detector damage can be avoided. Set up a regular schedule with a supplier of liquid nitrogen, and do not permit any delays in his delivery to upset this weekly filling schedule.

Keep the liquid nitrogen supply covered and free from contaminants before, during, and after it is furnished into the dewar. Always turn off the bias voltage to the detector before each refilling procedure, and leave it off during and after refilling; allow enough time (~20 min) after refilling to assure complete evaporation of any condensation that may occur, particularly in the vicinity of the preamplifier and high-voltage filter.

Models 80 and 81 can be filled automatically as described in Section 2 of the manual. The filling pressure should be furnished by clean dry nitrogen gas. Never use ordinary compressed air since it is likely to contain moisture and oil. Do not use oxygen or other gases because they are potentially hazardous. For the Model 85, just pour the liquid nitrogen into the dewar.

4.2. PACKING FOR RESHIPMENT

If the detector system is to be moved from one location to another by truck or plane, such as returning it to the ORTEC factory, fill the dewar with liquid nitrogen as close to the shipping time as practical.

The principle used in crating the detector is to provide solid support to secure the unit to the spring-loaded pallet within the crate and to then protect the unit with the one-piece cover bolted to the base. Steel or modern plastic strapping is appropriate for fastening the dewar to the pallet, and nylon reinforced tape is advised for the cryostat tie-down. Sponge rubber supports have been provided for critical support points. **Obtain a complete set of shipping materials and instructions from the ORTEC Customer Service Department before proceeding.** Shipping an improperly packaged system automatically voids its warranty.

To protect the detector system from damage due to warmup, be sure that the personnel at the detector relocation point know when it should be expected and are aware of the importance of liquid nitrogen supply maintenance. Transport the detector without tipping the dewar and refill the dewar with liquid nitrogen as soon as the unit is received, according to the procedures of Section 2 in this manual.

4.3. TROUBLESHOOTING SUGGESTIONS

Each ORTEC Ge(Li) Coaxial Detector is guaranteed to meet all performance specifications listed on the Quality Assurance Data Sheet. If there does appear to be a problem with a system, use the following troubleshooting procedures to identify the difficulty and to eliminate it.

The equipment that is required and the interconnections are shown in Fig. 3.1. Review the interconnections of the components and the dial settings of the instruments to ensure a proper system setup. In addition, the following items may be needed to resolve some of the problems that may be found: ohmmeter, gamma-ray source, and instruction manuals for all elements of the system.

The most common problems that may arise in a germanium detector system are listed below as symptoms. For each symptom the most probable cause(s) is listed, and repair procedures are suggested. The chief goals of this list are to aid in the intelligent analysis of the problem and to avoid lost use of the system while trying to decide whether or not the detector is operating satisfactorily. This can usually prevent any unnecessary delays, costs, and hazards of shipping the detector to the ORTEC factory and back. When a problem is identified that requires the detector to be returned to ORTEC, always summarize the symptoms observed and the tests that were performed and then call the ORTEC Customer Service Department at (615) 482-4411 to inform them of the details and to arrange for return and repair.

Check all power supply voltages and the detector bias supply polarity. Set the main amplifier controls as follows:

Gain	50
Input	Negative
Output	Positive
Output Range	10 V
Shaping	See Quality Assurance Data Sheet
BLR	Out

Connect the E output of the preamplifier to the Input of the main amplifier and connect the pulse generator output

to the Test input of the preamplifier. Connect an oscilloscope to the Unipolar output of the main amplifier.

Symptom — No output from main amplifier using gamma-ray source or pulse generator.
Check — Transfer the pulse generator output to the main amplifier input and furnish a test pulse with an amplitude of −0.1 V into the amplifier. If an output pulse is still absent from the main amplifier, the main amplifier is defective. The presence of an output pulse indicates a problem in the preamplifier or the detector.

Symptom — No preamplifier output using gamma-ray source or pulse generator with recommended operating bias applied, but output present when lower bias levels are used.
Cause — High detector leakage current biasing off the preamplifier input stage.
Repair — Decrease detector bias until an output is obtained from the preamplifier. A typical output is shown in Fig. 4.1. If operation at this lower bias does not meet the resolution specification, contact the ORTEC Customer Service Department at (615) 482-4411 for instructions.

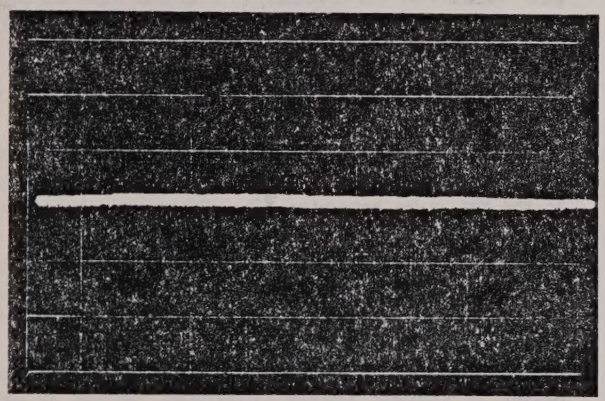


Fig. 4.1. Typical Preamplifier Output with Negative Pulse Spikes. (Vertical 0.01 V/cm; Horizontal 2 msec/cm.)

Symptom — No preamplifier output at any detector bias voltage.
Cause — Blown FET or shorted connection inside the cryostat.
Repair — Contact ORTEC Customer Service Department at (615) 482-4411.

Symptom — No preamplifier output when using a gamma-ray source, but output present when using the pulse generator.
Cause — Loss of connection from detector to preamplifier.
Repair — Notify ORTEC Customer Service Department at (615) 482-4411 of the problem.

Symptom — Multichannel analyzer does not register any incoming counts.
Cause — MCA set for coincidence operation, or analysis period aborted by its preset control.
Repair — See analyzer instruction manual and check control settings.

Symptom — Poor resolution from both the pulse generator and the gamma-ray source at detector operating bias, accompanied by excessive noise on the main amplifier baseline as shown in Fig. 4.2.
Cause — Excessive detector leakage current.
Check — Decrease detector bias level in 200-V steps until main amplifier linear output becomes stable, as shown in Fig. 4.3.
Repair — If detector resolution specification is not met at a lower bias setting, notify the ORTEC Customer Service Department at (615) 482-4411.

Symptom — Poor resolution at high or low count rates accompanied by misshaped peaks in the spectrum.
Cause — Lack of proper pole-zero cancellation in the main amplifier. This is not a detector problem.
Repair — Correct the pole-zero cancellation adjustment on the main amplifier. An improper adjustment causes either an undercompensation (undershoot not eliminated in the main amplifier output) or an overcompensation (output

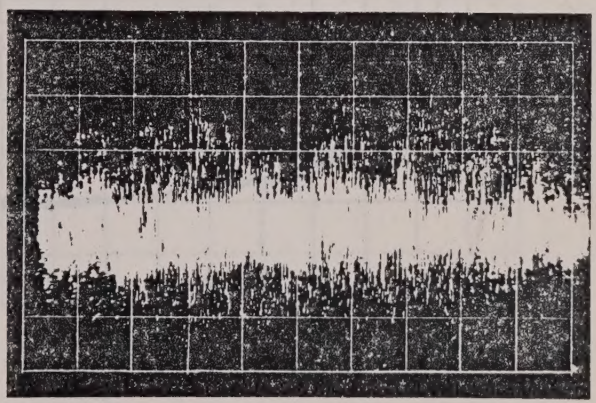


Fig. 4.2. Typical Amplifier Output with Excessive Noise. (Vertical 0.05 V/cm; Horizontal 0.5 msec/cm.)

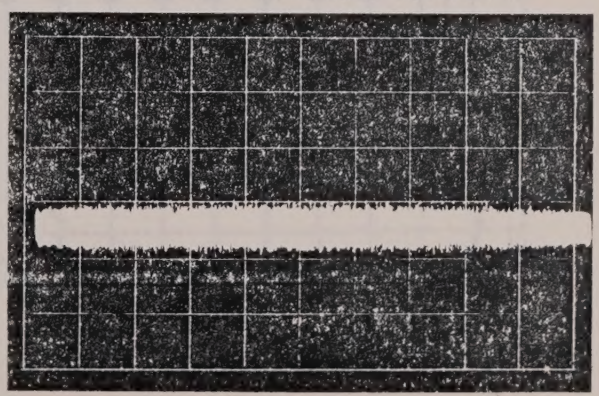
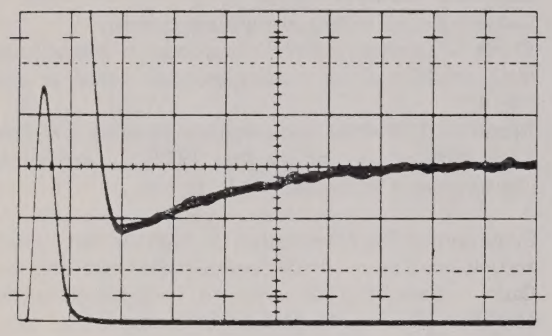


Fig. 4.3. Typical Amplifier Output with Acceptable Noise. (Vertical 0.05 V/cm; Horizontal 0.5 msec/cm.)

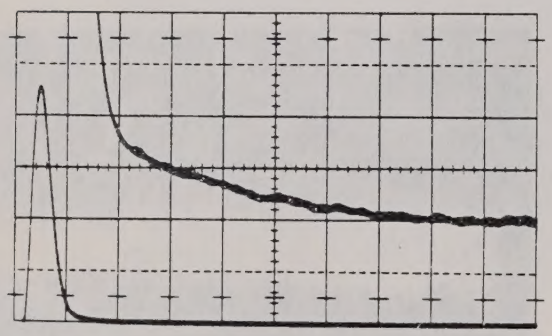
does not return directly to the baseline after an input pulse). See Fig. 4.4 for examples of how to properly adjust the pole-zero trim based on a monoenergetic input.

Symptom — Wandering peaks or poor pulse generator resolution, not accompanied by excessive noise in the main amplifier output and not dependent on detector bias.



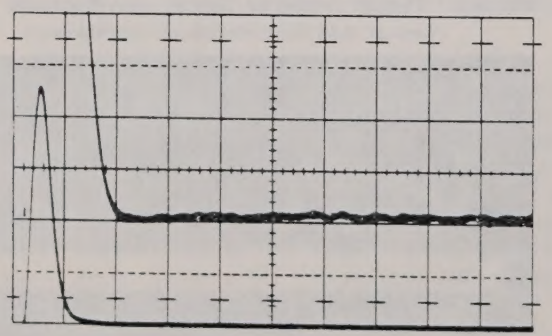
Undercompensated

Top Trace	0.02 V/cm
Bottom Trace	2 V/cm
Horizontal	20 μsec/cm



Overcompensated

Top Trace	0.02 V/cm
Bottom Trace	2 V/cm
Horizontal	20 μsec/cm



PZ Properly Adjusted

Top Trace	0.02 V/cm
Bottom Trace	2 V/cm
Horizontal	20 μsec/cm

Fig. 4.4. Pole-Zero Adjustments.

Cause — Unstable electronics. The excellent resolution of a Ge(Li) detector at high energies demands the ultimate in precision electronics.

Symptom — High loss rate of liquid nitrogen, possibly accompanied by an increased leakage current in the detector.

Cause — Loss of vacuum in the cryostat or leak in the dewar.

Check — If this is accompanied by a high detector leakage current, the problem is most likely a vacuum leak in the cryostat, and this is serious. The cryosorption material in the cryostat maintains a good vacuum until it becomes saturated, at which time it quickly loses its pumping ability. If possible, use another dewar full of liquid nitrogen to keep the cryostat cold while checking the loss rate of the system's dewar. Comparing the loss rates of the dewar alone with the dewar plus cryostat will indicate the loss rate for the cryostat alone. If the cryostat loses more than 1.0 liter/day (1.7 lb/day), its vacuum has probably deteriorated.

Repair — Due to the rapidly decreasing holding time with a poor vacuum in the cryostat, it is urgent that you notify the ORTEC Customer Service Department at (615) 482-4411 **immediately**. The ORTEC Customer Service Department will make arrangements for return of the detector system.

Symptom —. Degradation of resolution for high-energy gamma rays with little change of resolution for low energies or for the pulse generator. The photopeaks may have a low energy tail similar to those in Fig. 4.5.

Cause — Radiation damage or cryostat warmup. A dosage of as little as 10^8 neutrons is capable of creating significant trapping centers in the detector. Being warm for only a few hours will destroy the fine compensation attained in the detector element drifted region at the time of manufacture.

Repair — Contact ORTEC Customer Service at (615) 482-4411.

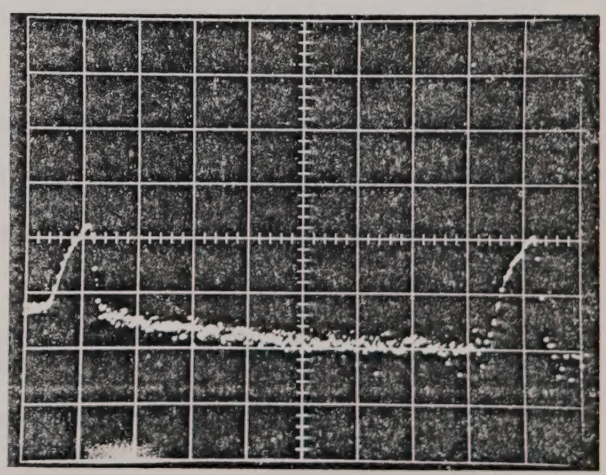


Fig. 4.5. Low-Energy Tailing in 1.17- and 1.33-MeV Photopeaks Due to Warmup. (Tailing due to radiation damage is very similar.)

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For more information on EG&G ORTEC products or their applications, contact your local EG&G ORTEC Representative or:

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